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HYBRID INTELLIGENT METHODS FOR PARAMETER IDENTIFICATION AND LOAD FREQUENCY CONTROL IN POWER SYSTEM

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Thesis submitted in fulfilment of the requirements
for the award of the degree of
Doctor of Philosophy in Electrical Engineering

Faculty of Electrical and Electronic Engineering
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LIST OF SYMBOLS

a	Participation factors
B	big
B	Frequency bias
c_1, c_2	acceleration coefficients
D	damping coefficient
d(n)	desired result
€	errors
G	length gain
G_{incr}	social acceleration coefficient
$G_1, G_2, \ldots, G_{incr}$	random number uniformly distributed in [0, G_{incr}].
G_{in1}, G_{in2}	input gain
G_{out}	output gain
G_{tg}	turbine governor transfer function
H	equivalent inertia constant
K(s)	dynamic controller
L1, L2 L, L’	horizontal distances
LN	large negative
LP	large positive.
M(p)	parametric model
M(s)	governor–turbine dynamic model
MN	medium negative
MP	medium positive
n(t)	input noise
pg	global best positions
p_i	local best positions
p_{incr}	cognitive acceleration coefficient
p_{i1}, p_{i2}., p_{incr}	random number uniformly distributed in [0, pincr]
R	droop characteristic
r_1, r_2	random numbers between 0 and 1.
S	small

SN	small negative
SP	small positive
T_{ij}	tie-line synchronizing coefficient with area j
u(n)	desired output
u(t)	input signal
VB	very big
$v_{i1}, v_{i2}, . . , v_{id}$	velocity of the i^{th} particle
V_{max}	maximum velocity value
VS	small
VVB	very very big
w(n)	adaptive transfer function configuration
X_{ij}	reactance
x(n)	input of in the implementation
$x_i, x_{i1}, x_{i2}, . . , x_{id}$	position of the particle
y(n)	actual output
y(t)	system output
ym(t)	output from the parametric model
Z	zero
β,α,δ	triangular angles
Δe	change of error
Δf	frequency change
ΔP_C	supplementary control action
ΔP_L	power load change
ΔP_m	governor valve position
ΔP_P	primary control action
ΔP_{tie}	net tie-line power flow
Ψ	class for models
ω	inertia weight parameter

LIST OF ABBREVIATIONS

ACE	Area Control Error
AFRC	Automatic Frequency Ratio Control
AGC	Automatic Generation Control
AGPM	Augmented Generation Participation Matrix
AI	Artificial Intelligence
ANN	Artificial Neural Network
BES	Battery Energy Storage
CES	Capacitive Energy Storage
FD	Figure Of Demerit
GAs	Genetic Algorithms
GRC	Generation Rate Constraint
$H\infty$	Robust Controller
HVDC	High Voltage Direct Current
IGBT	Insulated Gate Bipolar Transistor
ISE	Integral Square Error
ITAE	Integral Of Time Of Absolute Error
LFC	Load Frequency Control
LMI	Linear Matrix Inequality
LQG	Linear Quadratic Gaussian
LSE	Least Square Estimator
MLE	Maximum Likelihood Estimator
MOO	Multi-Objective Optimization
MSF	Multi-Stage Fuzzy
PD	Proportional Plus Derivative
PI	Proportional Plus Integral
PID	Proportional, Integral And Derivative
PSO	Particle Swarm Optimization
PV	Photovoltaic
RBF	Radial Biased Function
RTO	Real-Time Optimization

SA	Simulated Annealing
SePSO	Segmentation of Particle Swarm Optimization
SMES	Super Conducting Magnetic Energy Storage
SOFLC	Self Organizing Fuzzy Logic Control
SVC	Static Var Compensator
WLS	Weighted Least Squares

ABSTRACT

The accuracy of the parameter identification of power system model and efficiency of frequency control are part of the challenging work in power system operation and control area. Whereas, the complexity and high non-linearty of the power system model have led to the continuing research for improvement that still extensively active, especially for load frequency control (LFC). Generally, LFC is responsible to maintain the zero steady-state errors in the frequency changing and restoring the natural frequency to its normal position. Many methods have been proposed and implemented in identification of power system and LFC, however, they may not be appropriate. For example, the classical methods for parameter identification (LSE and MLE), the classical methods for LFC (PI, PD and PID) and the intelligent methods (fuzzy logic, neural network, genetic algorithm, and PSO). Thus, motivated from the topics, this Thesis is brought to present the improvement of the parameter identification of power system model and the response of the LFC in power system. The Thesis is divided into two parts in accordance to the topic. Where, in the first part, the coherent identification algorithm for single and multi-area power systems with disturbances is proposed. A new method from the improvement of Particle Swarm Optimization (PSO) is developed in order to find the best global optimal value. Meanwhile, part two presents three developed control methods for FLC from the improvement of fuzzy control (named as scaled fuzzy using PSO, parallel conventional PI/PD with Scaled Fuzzy PI/PD and Mirror Fuzzy controller) by adapting the utilization of PSO to optimize the scaled gain of fuzzy controllers. These proposed control methods in LFC will be examined and verified in two and four areas power system. The outcomes of the proposed parameters identification and LFC control methods are presented the results through simulation using Matlab by making a comparison on the frequency transient response. Various analyses are shown and the discussions on the results are done appropriately. Lastly, the Thesis is given the concluding remarks and the contributions which can be specified into two, a modification of PSO for parameters identification named as PSO segmentation and a new fuzzy control named as a Mirror Fuzzy controller for LFC.

ABSTRAK

Ketepatan pengenalan sistem kuasa dan kawalan adalah salah satu cabaran utama untuk dunia terutamanya yang sangat kompleks atau sistem tak lelurus seperti Kawalan Beban Frekuensi (LFC). LFC bertanggungjawab untuk mengekalkan sifar ralat keadaan mantap dalam kekerapan berubah dan mengembalikan frekuensi semula jadi untuk kedudukan asal . Sebagai contoh, kaedah klasik untuk mengenal pasti parameter (LSE dan MLE), kaedah klasik untuk LFC (PI, PD dan PID) dan kaedah pintar (logik kabur, rangkaian neural, algoritma genetik, dan PSO). Tesis ini dibahagikan kepada dua bahagian mengikut topik . Dalam Bahagian 1, kita hadir koherensi berasaskan algoritma pengenalan untuk membina kawasan tunggal , dan pelbagai sistem kuasa , dengan menggunakan ayunan frekuensi antara kawasan dominan berikutan gangguan dalam sistem. Salah satu masalah utama dalam analisis dinamik dan kawalan sistem kuasa adalah analisis sistem fenomena fana daripada data pengukuran terhad. Dalam tesis ini semula kaedah yang membangunkan untuk mengenal pasti model menggunakan segmentasi PSO .Dalam Bahagian 2, tiga kaedah membangunkan untuk mengawal kekerapan , salah seorang daripada mereka adalah dengan menggunakan gabungan PSO dan kawalan logik kabur teknik (FLC), yang dipanggil PSO- Skala Kawalan Fuzzy . PSO kaedah pengoptimuman digunakan untuk memperhalusi kabur input pengawal dan output keuntungan untuk memberikan sempadan optimum had keahlian kabur. Kaedah ini dikaji pada dua dan empat bidang sistem kuasa.Kaedah pertama dibangunkan untuk mendapatkan kaedah yang kedua, yang mewakili gabungan antara Fuzzy PSO- Skala dan pengawal konvensional. Dua jenis parallelization dalam kaedah ini ; satu adalah sambungan antara PI Fuzzy dan PD konvensional. Dua adalah sambungan antara PD Fuzzy dan PI konvensional.Kaedah ketiga juga sedang membangunkan kaedah penumbuk , PSO kaedah pengoptimuman digunakan untuk memperhalusi kabur input pengawal dan output keuntungan sebagai partition untuk memberikan sempadan had optimum dan bentuk segi tiga daripada keahlian kabur. Dua bidang sistem kuasa digunakan untuk membangunkan, dan menyiasat kaedah ini. Kaedah ini Dinamakan Mirror Fuzzy kawalan

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Appendix D

PUBLICATIONS

D.1 Publications injournals

(i) ‘Advance Two-Area Load Frequency Control Using Particle Swarm Optimization Scaled Fuzzy Logic’; Aqeel S. Jaber, Abu Zaharin B. Ahmad, Ahmed N Abdalla; Advanced Materials Research Vols. 622-623 (2013) pp 80-85.

(ii) ‘A New Load Frequency Controller based on Parallel Fuzzy PI With Conventional PD (FPI-PD)’; Aqeel S. Jaber, Abu Zaharin Ahmad, Ahmed N. Abdalla; International Journal of Electronic Science and Engineering vol:7 No: 2 2013.

(iii) ‘An Investigation of Scaled-FLC Using PSO for Multi-area Power System Load Frequency Control’; A. S. Jaber, A. Ahmad, and A. Abdalla; Energy Power Eng., vol. 5, pp. 458–462, 2013.

(iv) ‘A New Load Frequency Controller based on Parallelization of Fuzzy PD with Conventional PI(FPD-PI)’; Aqeel S. Jaber, Abu Zaharin B. Ahmad, Ahmed N. Abdalla; Australian Journal of Basic and Applied Sciences vol. 8(4) pp. 373-379, 2014.

D.2 Publications in conferences

(i) ‘Efficient Load frequency control based on intelligent PI Controller of Tow Area Power System’; Aqeel S. Jaber, Abu Zaharin B. Ahmad, Ahmed N Abdalla, Nadheer A. Shalash; Electrical, Electronic and Control Technology (MCEECT 2012).

(ii) ‘A New Parameters Identification of Single Area Power System Based LFC Using Segmentation Particle Swarm Optimization (SePSO) Algorithm’; Aqeel S. Jaber, Abu Zaharin Ahmad, Ahmed N. Abdalla; IEEE PES Asia-Pacific Power and Energy Engineering Conference 2013.

(iii) ‘A Novel Load Frequency Controller based on Parallel Operation of Fuzzy PD with Conventional PI (FPD-PI)’; Aqeel S. Jaber, Abu Zaharin B. Ahmad, Ahmed N. Abdalla;2nd power and energy conversion symposium (PECS)2014.